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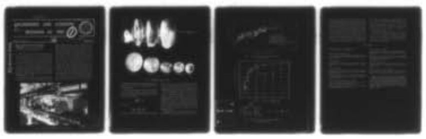

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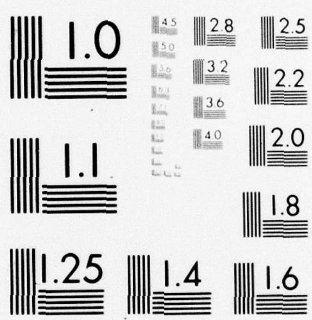

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ENGINEERING AND SCIENTIFIC RESEARCH AT WES

Miscellaneous Paper 0-74-1 February 1974

TIRE SELECTION FOR OFF-ROAD VEHICLES, *by G. W. Turnage, Mobility and Environmental Systems Laboratory*

Wheeled vehicles are being used off-road today more than at any time in our history. The "all-terrain" pleasure vehicle for outdoorsmen is only a few years old; companies concerned with timber harvesting, mining, surveying, and other earth-related activities have drastically increased their off-road use of wheeled vehicles; and the military, now as much as ever, needs and uses wheeled vehicles for troop deployment and supply. Accompanying the increased use of wheeled vehicles in off-road activities is the increased need for an ability to predict vehicle performance both quantitatively and accurately.

Achievement of vehicle performance prediction capability has been sought at the Waterways Experiment Station (WES) through a balanced program of basic laboratory research and field testing of full-scale vehicles. Many systematic tests have been conducted in a controlled laboratory environment with single pneumatic tires in dynamometer carriage-soil car arrangements (fig. 1). The basic objective has been the development of techniques to allow scaling of the model wheel test results to predict prototype behavior. To accomplish this, tires of a broad range of sizes and shapes have been tested under an extremely wide range of wheel loads and on many soil strengths. Tire outside diameters ranged from 8 to 41 in., widths from 2 to 15 in., and diameter-to-width ratios from 1:1 to 16:1. Tires with conventional, near-circular cross sections (fig. 2) and those with low-profile, near-rectangular cross sections (fig. 3) were used. Two principal soil types that, in most cases, present the most severe problems to wheeled vehicle mobility were used: one that derives

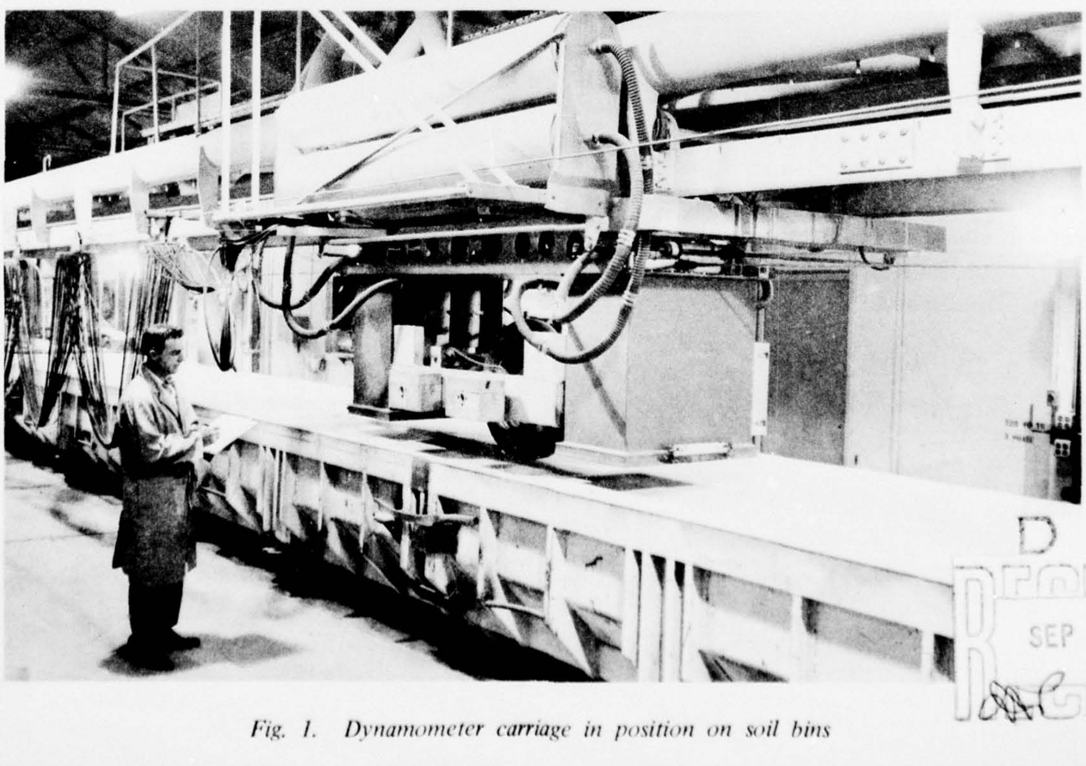

Fig. 1. Dynamometer carriage in position on soil bins

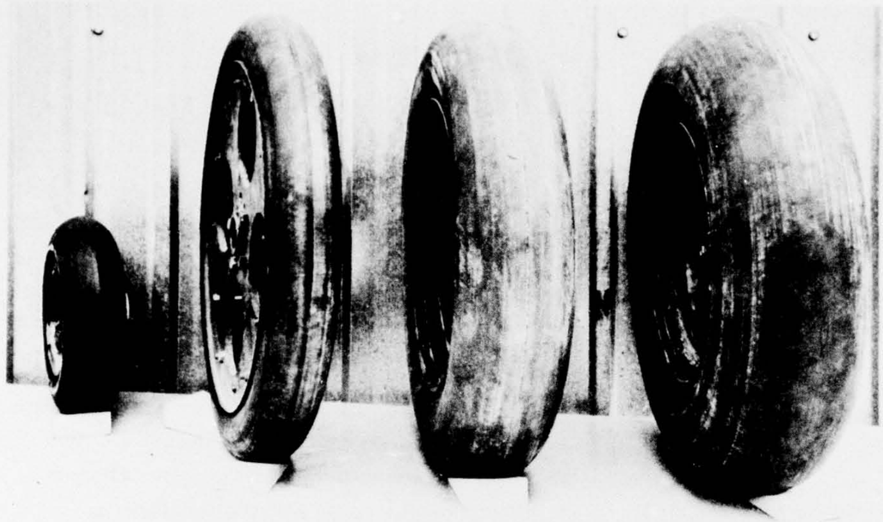

Fig. 2. Circular-cross-section tires

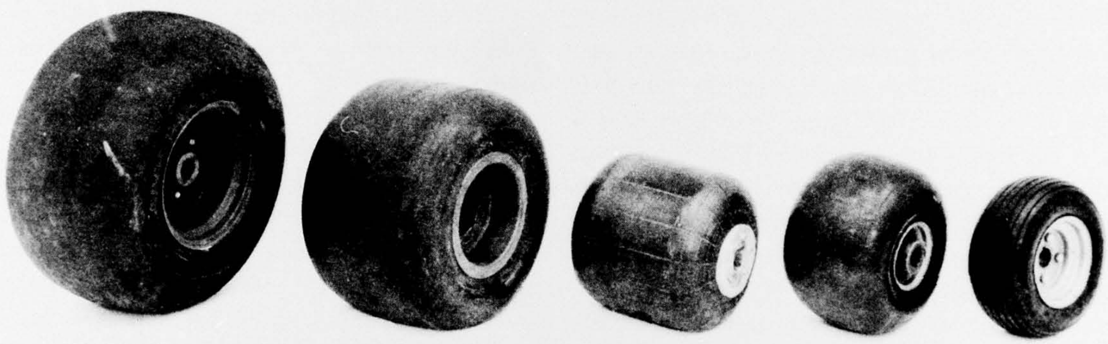

Fig. 3. Rectangular-cross-section tires

essentially all its strength from friction (air-dry sand), and another that gains nearly all its strength from cohesion (near-saturated clay).

Results of the laboratory tests were interpreted by means of dimensional analysis to develop two terms that can be used to predict wheel performance in sand and clay, respectively. These terms,

$$\frac{G(bd)^{3/2}}{W} \cdot \frac{\delta}{h}$$

for sand and

$$\frac{RCI}{W} \cdot \frac{2bd^2}{2d+b} \cdot \left(\frac{\delta}{h}\right)^{1/2}$$

for clay, incorporate the soil-wheel parameters considered to be the most pertinent in any wheeled vehicle prediction scheme: soil strength (G and RCI for sand and clay, respectively); wheel load (W); and tire outside width (b), outside diameter (d), section height (h), and deflection (δ).

Both dimensionless prediction terms are closely related to the following important tire performance coefficients: pull/load, torque/(load × active tire radius), sinkage/diameter, and towed force/load. The first three coefficients are measured at 20 percent slip, a powered condition that produces near-maximum pull on both sand and clay without excessive loss in forward translational velocity; the fourth is the pull necessary to tow an unpowered wheel.

Relations of the two terms to the pull coefficient for full-size wheeled vehicles are illustrated in figs. 4 and 5.

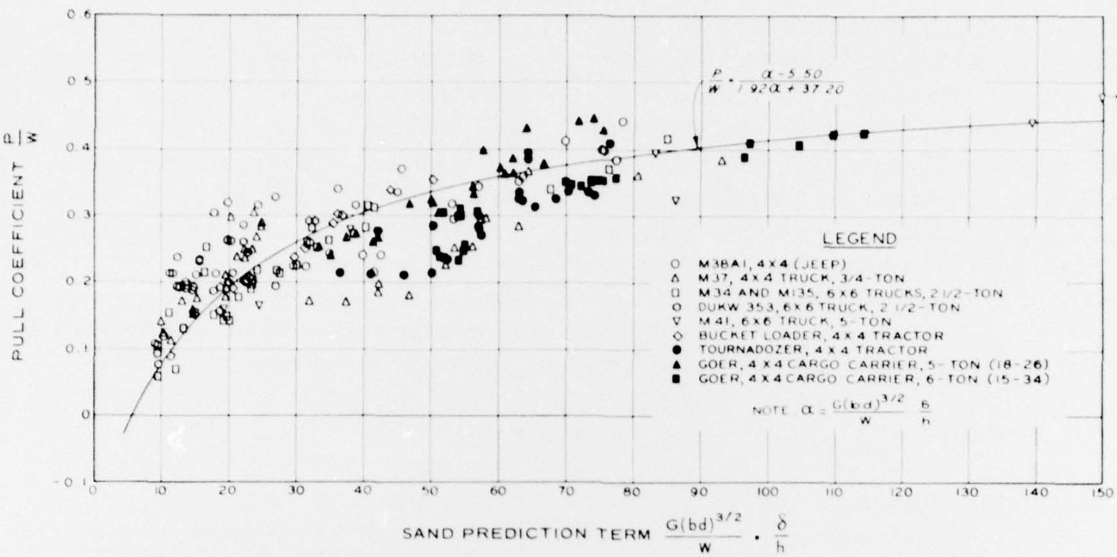

Fig. 4. Results of field tests of wheeled vehicles in dry-to-moist sand

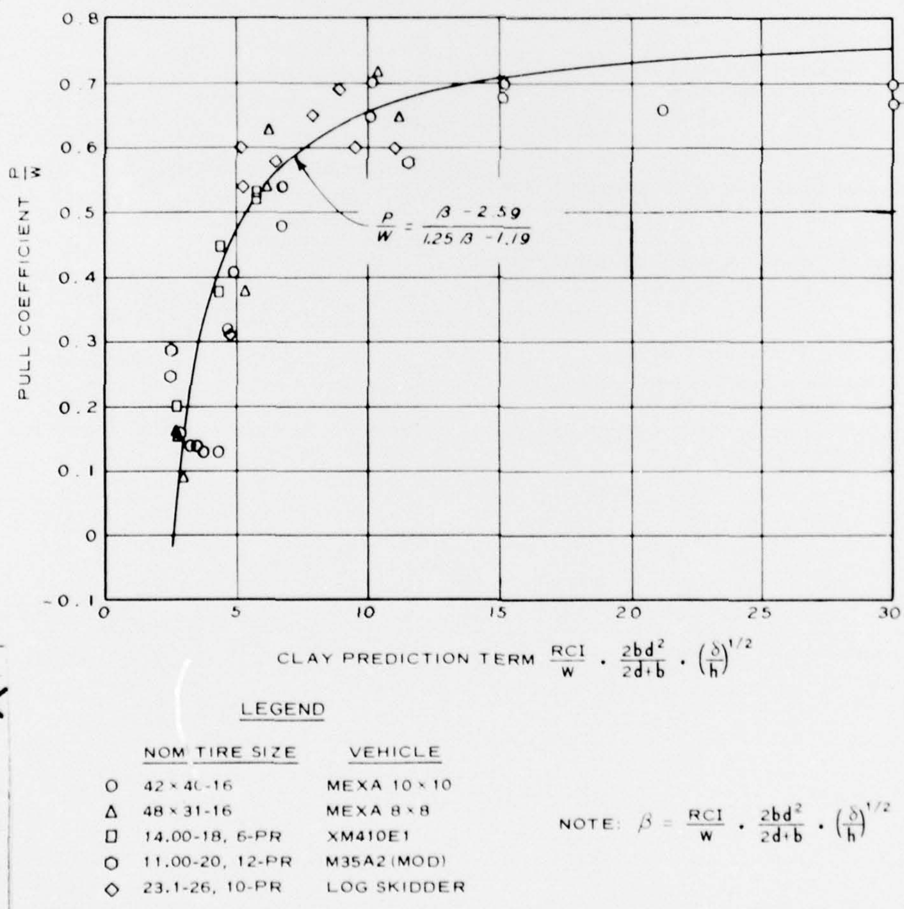

Fig. 5. Results of field tests of wheeled vehicles in wet, fine-grained soils

Data in these two figures were obtained with a wide variety of vehicle configurations, wheel loads, and tire sizes, shapes, tread patterns, and deflection conditions in tests at various locations around the world. The curves of best fit for these data can be used to predict the pull performance of existing or proposed wheeled vehicles in practically any given wheel load-soil strength situation, and to choose or design tires for a given vehicle to attain a given level of off-road performance. One dramatic example of this is the success achieved by use of a modified version of the WES system in selecting the wheel configuration used on the Lunar Rover Vehicle and in predicting its power consumption rate on the moon. In another study that illustrates the usefulness and versatility of the system, an 8x8 test bed and a 10x10 test bed were designed for use in transporting a 2-1/2-ton load on clay so soft that a man would have extreme difficulty walking on it.

The WES system for tire selection for off-road vehicles has made "seat-of-the-pants" judgments concerning large-scale off-road wheeled vehicle movements obsolete; the expertise is now available to predict this performance quantitatively and accurately.

★ ★★★★

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